New Capabilities and Performance of the Fermilab Meson Test Beam Facility

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***Abstract*–The Fermilab Meson Test Beam Facility is a beamline where users can test detectors and other equpment in a moderate flux particle beam, tunable from 1 to 120 GeV in energy. Several new capabilities have been added to this facility in the last year. These include a differential Cerenkov counter, a large area pixel telescope and a new tertiary beamline that can deliver beam down to very low energies - on the order of 300 MeV. The facility has been used to test many different types of detectors, which have, in turn, resulted in a better understanding of the beamline. I will discuss the performance of the beamline, the new facility detectors and some results from the experiments performed there.**

I. Introduction

THE Fermi National Accelerator Laboratory, in Batavia, Illinois, is the United States' premiere high energy physics laboratory, catering to users from around the world. One aspect of the mission of the laboratory is to support the development and testing of high energy detectors. To that end, the laboratory oversees detector testing experiments in the Meson Test Beam Facility (MTest). This facility has been in operation for several years now, and has hosted dozens of experiments.

This facility accepts beam from the Main Injector accelerator (MI) which delivers protons at an energy of 120 GeV. That beam can either be delivered to the user areas, or it can be impinged on one of two movable targets, to provide a secondary beam of lower energy and of mixed composition. The user areas of the MTest facility can accommodate several users at once, using the same beam. It contains a series of beam monitoring devices so that users know what type of beam is being delivered. This paper describes upgrades to the facility and its recent performance.

II. Description of Beam Extraction

The test beam originates from the acceleration and then resonant extraction, inside the MI, of at least one batch of protons delivered from the 8 GeV 'Booster'. This batch usually consists of 60-80 RF 'buckets', with each bucket 19 nsec long. Thus the batch is about 1.5 microseconds long. The full circumference of the MI is about 10 microseconds. It is possible to run with up to 5 Booster batches in the MI. The batch or batches are accelerated to 120 GeV, circulate around the MI and are resonantly extracted over a macroscopic slow spill. For most usage of the test beam, there will be less than 100 kHz of beam. If beam were smoothly extracted, this would imply that at most 1 particle per rotation of the MI batch will occur. The beam is not that smooth and we see on the order of 5-15% double occupancy per MI rotation. The length and duty cycle of the spill is determined by the AD, with guidance from Program Planning. During 2007 it was a single 3.6 second long spill per minute, for a maximum of 12 hours per day.

The beam has an approximately 3% momentum spread and can be focused to a 7 mm RMS spot size for 120 GeV protons and approximately 2-5 cm RMS spot for the lower momenta. Table 1 shows the rates achieved in the beamline for 1E11 protons in the Main Injector.

TABLE I
BEAM RATES IN THE MTEST FACILITY

Beam Energy (GeV)	Rate at Entrance to MT6 (per spill)	Rate at Exit of MT6 (per spill)	%Pions, Muons at exit of MT6	% Electrons at exit of MT6
16	132,000	95,000	82%	18%
8	89,000	65,000	42%	58%
4	56,000	31,000	26%	72%
2	68,000	28,000	<10%	>90%
1	69,000	21,000	<10%	>90%

III. The User Facility

Figure 1 shows the areas available to users to set up test equipment. There are 6 areas along the beamline, with beam monitoring available at most locations. Signal and high voltage cables are available at each location, leading to the control room. Gas and exhaust lines are also available at each location.

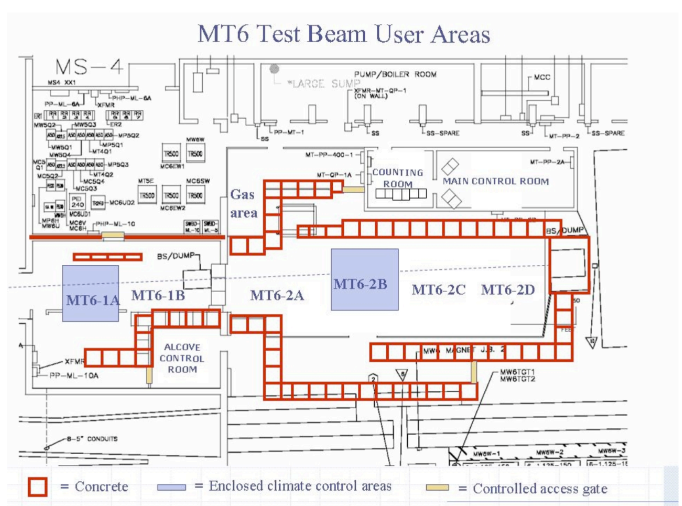

Fig. 1. A plan view of Fermilab's Meson Test Beam Facility.

IV. New Capabilities of the Beam

The Fermilab Accelerator Division (AD) is implementing the ability to switch simply from the 3.6 second spill to a 1.0 second spill. For the same impact on the rest of the Fermilab program, this shorter spill could then be delivered more frequently for commissioning purposes and for those groups who are buffer DAQ limited.

As well, the AD is studying a faster mode of extraction, using pulsed current going into the quadrupole resonant extraction magnet. This mode can deliver beam with a few millisecond pulse width, and repeat this extraction every 200 milliseconds. This beam delivery is a reasonable approximation of the International Linear Collider (ILC) beam structure, and thus can be used to test ILC detectors.

A simulation of the beamline, using a GEANT4 wrapper called G4BEAMLINE, has led to an understanding of how dense metal foils can be inserted at the focal point of the beam, to reduce the electron content.

The most significant addition to the MTest facility's beam capabilities is the construction of a tertiary beamline in the MT6 Section 2 area. This beamline takes 8 GeV secondary beam and impinges it on a short aluminum target. A small spectrometer magnet, collimator and associated tracking allows for selection of very low energy tertiary particles, with momenta as low as 300 MeV/c.

V. New Detectors in the User Facility

Several new detectors have been commissioned for the MTest facility. One of these is a differential Cerenkov counter, shown in figure 2. This device, which can discriminate on Cerenkov ring size, can be used to trigger on a minority particle species such as kaons or muons in the beam.

Another major new facility detector for users is a 4 plane pixel telescope, with approximately 20 micron resolution for single hits. This detector uses PHENIX pixel sensors, read out with an upgraded FPIX chip.

VI. Research Performed at the New Facility

Each test beam experiment is required to form a Memorandum of Understanding with the laboratory, in which beam and infrastructure requirements are spelled out in detail. Several major new experiments were approved and took data during 2008.

The largest detector test performed at the MTest facility was installed in April, 2008. It is the CALICE detector, which is a major international ILC calorimeter research collaboration. Their installation is shown in Figure 3. It contains a versatile motion table with absorber plates for supporting tests on different types of hadronic calorimeter read out planes, as well as infrastructure to support electromagnetic calorimeter research.

VII. Conclusion

Fermilab has supported a significant upgrade to its detector test beam facility which allows for improved delivery of beam and monitoring of beam conditions. This MTest facility is open to users from around the world for appropriate experiments.

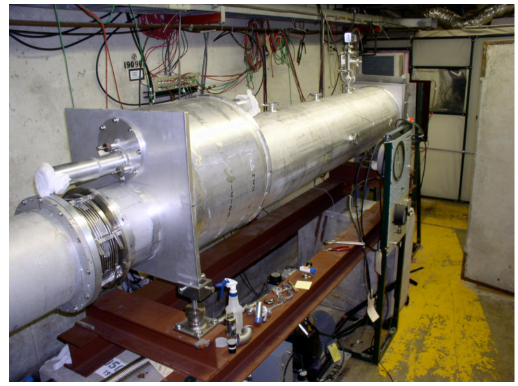

Fig. 2. The new differential Cerenkov counter.

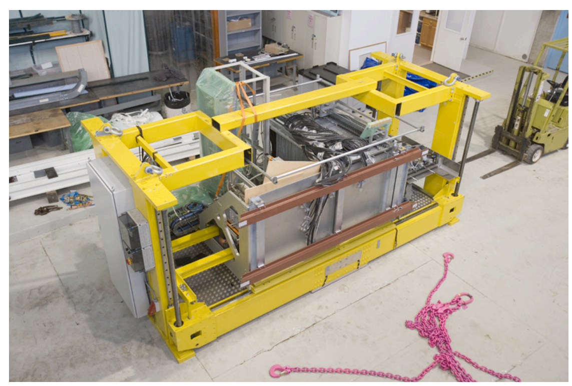

Fig. 3. A view of the CALICE installation.